

BRYOPHYTES OF SALINE AREAS IN THE PANNONIAN REGION OF SERBIA AND CROATIA

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Abstract: Altogether 40 species (5 liverworts and 35 mosses) were collected in the studied saline grasslands in the Pannonian region of Serbia and Croatia. The following bryophyte species are characteristic both in the Serbian and Croatian sites: *Barbula unguiculata*, *Brachythecium albicans*, *Bryum algovicum*, *B. dichotomum*, *B. ruderae*, *Didymodon sicculus*, *Drepanocladus aduncus*, *Microbryum davallianum*, *M. floerkeanum*, *Phascum cuspidatum*, *Protobryum bryoides*, and *Pseudocrossidium hornschi*. Most of these are typical elements of the bryophyte assemblages living on the saline-alkaline grasslands of the Danube–Tisza Interfluvium in Hungary. *Didymodon sicculus* is reported for the first time in Croatia here. *Microbryum floerkeanum* is included in the Red data book of European bryophytes. In addition, in the studied Serbian saline sites another European red-listed species, *Entosthodon hungaricus*, is also present. Two thalloid liverworts, rare in SE Europe, *Oxymitra incrassata* and *Riccia nigrella*, were found in one Serbian site.

Key words: liverworts, mosses, new national record, SE Europe, threatened species

INTRODUCTION

The salt grasslands of the Pannonian region are the westernmost representatives of this habitat of the Eurasian steppe zone and they are the largest in East Central Europe; about 5,500 km² in Hungary (MOLNÁR 1997). They occur mainly in the Great Hungarian Plain, in the former inundation areas of the Danube and Tisza rivers, and in the depressions of the sand and loess plateaus. However, near the Hungarian border in Serbia and Croatia some small extension remnants of saline areas can also be found, which form a single unit with the Hungarian salt grasslands. These are fragmented areas embedded in a typical agricultural landscape.

Pannonian salt steppes and salt marshes are priority habitat types in Europe according to the European Union Habitats and Species Directives (EEC 1992).

The most important condition of the formation of such areas is the relatively high level of saline groundwater under continental or semi-arid climate (MOLNÁR 1997). Most of the Pannonic salt grasslands were formed in the Holocene (MOLNÁR 1997). The water regime of the alkali soils is very extreme, because the salt content is high near the surface. Therefore there is a close correlation between microrelief, water regime, salt content, soil properties and the floristical composition, which resulted in a mosaic-like appearance of the plant communities (MOLNÁR 1997). The marginal, transitional or border zones of various communities are advantageous for the establishment of bryophytes. Among tussocks on the bare soil surface rich bryophyte vegetation can be found. Mainly in spring several colonist species appear (PAPP and RAJCZY 2000).

Whereas in Hungary the bryophyte flora of salt grasslands is well-explored (ORBÁN 1982, PAPP and RAJCZY 1999, 2000), in the southern neighbouring countries salt areas are bryologically neglected habitat types. In Serbia, there was an earlier investigation on the cryptogam flora of the surroundings of Senta town carried out by János Guelmino in the 1970s (GUELMINO 1973). His compilation contained only 12 bryophyte species collected from saline areas. The specimens were identified by the Hungarian bryologists István Györffy and Ádám Boros. Later on, another species, *Riccia nigrella*, was detected by Beáta Papp in an *Oxymitra incrassata* specimen collected by Guelmino (SABOVLJEVIĆ *et al.* 2010). Guelmino's specimens are deposited in the Bryophyte Collection of the Hungarian Natural History Museum, Budapest (BP). In Croatia there were no earlier bryological investigations in salt grasslands.

MATERIAL AND METHODS

Study area

The investigated saline grasslands in Serbia are situated around Senta town at Trešnjevac, Velebit, and Padej villages, while in Croatia at Trpinja village (Fig. 1). These are flat areas at low elevation (80–100 m a.s.l.) characterised by continental climate with high daily and yearly temperature fluctuations as well as relatively low air humidity. Although during spring large areas are covered by water, drought is frequent in summer (GUELMINO 1968, TOPIĆ & VUKOVIĆ 2010 ZANINOVIĆ 2008).

In the grasslands around Senta town in Serbia the main species of the lower, wetter areas are *Bolboschoenus maritimus* (L.) Palla, *Eleocharis palustris* (L.) R. et Sch., and *Juncus gerardii* Loisel., while on the drier parts at somewhat higher elevations *Puccinellia distans* (L.) Parl. subsp. *limosa* (Schur) Jáv., *Agrostis stolonifera* L., *Festuca pseudovina* Hackel ap. Wiesb. are predominant. The lowest places are covered by the most heavily salt-affected (and salt-tolerant) plant community with the predominance of *Camphorosma annua* Pallas (GUELMINO 1968).

The surrounding of Trpinja village in Croatia is a typical agricultural area with the dominance of arable fields criss-crossed by a network of channels. The pastures with a mosaic of salt tolerant plant communities are spread on a surface of 4.5 ha, but the characteristic halophytic association *Camphorosmetum annuae* Rapaics ex Soó 1933 occupies not more than 1.5 ha. Beside *Camphorosma annua*, some other plant species characteristic for Pannonic salt steppes are *Puccinellia distans* subsp. *limosa*, *Aster tripolium* L. subsp. *pannonicus* (Jacq.) Soó, *Plantago tenuiflora* Waldst. et Kit., *Podospermum canum* C. A. Mey., *Carex divisa* Huds., *Achillea setacea* Waldst. et Kit. and some others. Water, remaining in shallow depressions, enables the formation of hygrophilous communities dominated by *Juncus compressus* Jacq. (TOPIĆ and VUKOVIĆ 2010).

The salt pastures at Trpinja are included in the NATURA 2000 network as a site for priority habitat type 1530 (Pannonic salt steppes and salt marshes) (EEC 1992). The site is also considered as Important Plant Area and proposed for protection as Special reserve of grassland vegetation (IUCN category IV) with the purpose of protection of rare and in Croatia unique vegetation of continental salt habitats (BORŠIĆ *et al.* 2011).

Site details

1. Serbia, Vojvodina, N Banat, at Trešnjevac (Oromhegyes) village near Senta town, 45.988583° N, 20.008944° E, 85 m, 06.04.2010. – 2. Serbia, Vojvodina, N Banat, at Velebit village near Senta town, 46.010772° N, 19.952594° E, 90 m, 06.04.2010. – 3. Serbia, Vojvodina, N Banat, at Padej village near Senta town, 45.841333° N, 20.164833° E, 80 m, 06.04.2010. – 4. Croatia, W Srijem, Trpinja village, 45.427027° N, 18.900694° E, 100 m, 12.05.2013.

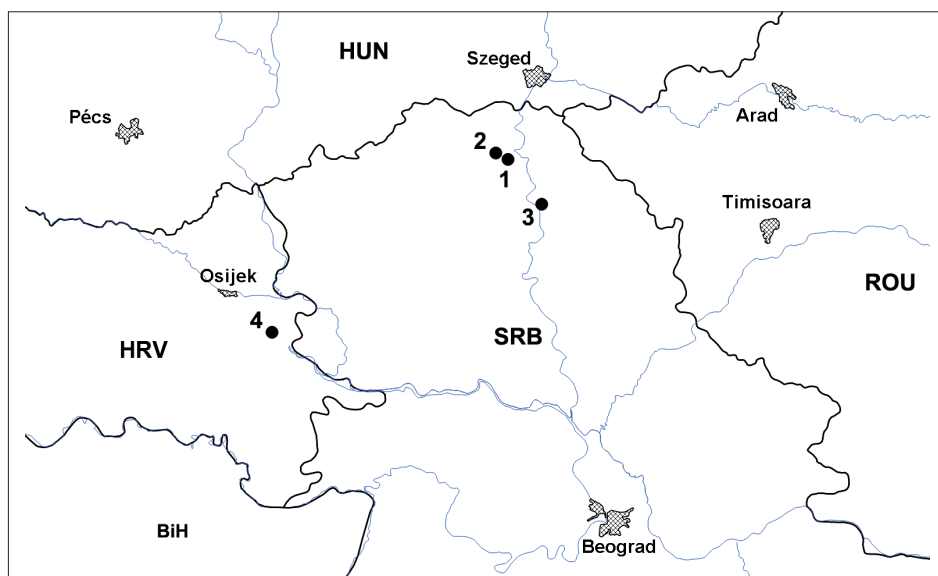


Fig. 1. Location of the investigated sites.

Methods

The specimens are deposited in the Herbarium of the Hungarian Natural History Museum, Budapest (BP) and the Herbarium Croaticum of the University of Zagreb (ZA). Nomenclature follows GROLLE and LONG (2000) for liverworts and HILL *et al.* (2006) for mosses. European distribution of the species is given according to DÜLL (1983, 1984, 1985).

RESULTS

Altogether 40 species (5 liverworts and 35 mosses) were collected in the investigated saline grasslands, 19 at Trešnjevac, 19 at Velebit, 27 at Padej in Serbia, and 17 at Trpinja in Croatia, respectively. The list of bryophytes found is shown in Table 1.

DISCUSSION

All of the species from the salt grasslands around Senta town recorded by GUELMINO (1973) were re-found in the studied sites in Serbia. These were the following: *Oxymitra incrassata*, *Riccia ciliifera*, *R. nigrella*, *R. sorocarpa*, *Barbula unguiculata*, *Brachythecium albicans*, *Bryum alpinum*, *Entosthodon hungaricus*, *Phascum cuspidatum*, *Polytrichum juniperinum*, *Protobryum bryoides*, *Pterygoneurum ovatum*, *Tortula lanceola*.

Many sub-Mediterranean and sub-Atlantic bryophyte species are characteristic at the sites like *Bryum ruderales*, *Didymodon sicculus*, *D. vinealis*, *Microbryum curvicolle*, *M. davallianum*, *M. floerkeanum*, *Protobryum bryoides*, and *Pseudocrossidium hornschi*. A continental, Mediterranean element, *Entosthodon hungaricus* can also be mentioned here. Besides these, species of the temperate zone of Europe also occur like *Barbula unguiculata*, *Bryum algovicum*, *B. dichotomum*, *Phascum cuspidatum*, *Pterygoneurum ovatum*, and in wetter places *Brachythecium mildeanum* and *Drepanocladus aduncus*. A subboreal species, *Brachythecium albicans*, is also a constant element of the bryophyte assemblage of the investigated saline grasslands. Most of the above-mentioned species are calcicolous and they are also characteristic elements of the bryophyte vegetation living on the salt grasslands of the Danube–Tisza Interfluvium in Hungary, where the lime content in the soil is usually also high (PAPP and RAJCZY 1999, 2000).

The bryophyte flora of the grasslands at Padej is different from the other studied sites. The bryophyte diversity is higher due to the occurrence of some additional Mediterranean and sub-Mediterranean thalloid liverworts (*Oxymitra incrassata*, *Riccia ciliifera*, *R. nigrella*) and mosses (*Aloina ambigua*, *Bryum alpi-*

Table 1. List of species found at the studied sites.

	Trešnjevac, Serbia	Velebit, Serbia	Padej, Serbia	Trpinja, Croatia
Liverworts				
<i>Cephaloziella divaricata</i> (Sm.) Schiffn.			+	
<i>Oxymitra incrassata</i> (Brotero) Sergio et Sim-Sim			+	
<i>Riccia ciliifera</i> Link ex Lindenb.			+	
<i>Riccia nigrella</i> DC.			+	
<i>Riccia sorocarpa</i> Bisch.			+	
Mosses				
<i>Aloina ambigua</i> (Bruch et Schimp.) Limpr.			+	
<i>Barbula unguiculata</i> Hedw.	+	+	+	+
<i>Brachythecium albicans</i> (Hedw.) Schimp.	+	+	+	+
<i>Brachythecium mildeanum</i> (Schimp.) Schimp.		+		+
<i>Bryum algovicum</i> Sendtn. ex Müll.Hal.	+		+	+
<i>Bryum alpinum</i> Huds. ex With.			+	
<i>Bryum caespiticium</i> Hedw.	+			
<i>Bryum dichotomum</i> Hedw.	+		+	+
<i>Bryum ruderales</i> Crundw. et Nyholm	+	+		+
<i>Ceratodon purpureus</i> (Hedw.) Brid.			+	
<i>Dicranella howei</i> Renaud et Cardot				+
<i>Dicranella varia</i> (Hedw.) Schimp.				+
<i>Didymodon acutus</i> (Brid.) K. Saito		+	+	
<i>Didymodon sicculus</i> M. J. Cano, Ros, García-Zamora et J. Guerra	+	+	+	+
<i>Didymodon vinealis</i> (Brid.) R. H. Zander	+			+
<i>Ditrichum flexicaule</i> (Schwägr.) Hampe			+	
<i>Drepanocladus aduncus</i> (Hedw.) Warnst.	+	+	+	+
<i>Entosthodon hungaricus</i> (Boros) Loeske	+	+	+	
<i>Funaria hygrometrica</i> Hedw.		+		
<i>Homalothecium lutescens</i> (Hedw.) H. Rob.	+	+		
<i>Microbryum curvicolium</i> (Hedw.) R. H. Zander	+	+		
<i>Microbryum davallianum</i> (Sm.) R. H. Zander	+	+		
<i>Microbryum floerkeanum</i> (F. Weber et D. Mohr) Schimp.	+	+		+
<i>Oxyrrhynchium hians</i> (Hedw.) Loeske	+			+
<i>Phascum cuspidatum</i> Hedw.	+	+	+	+
<i>Pleurochaete squarrosa</i> (Brid.) Lindb.			+	
<i>Polytrichum juniperinum</i> Hedw.			+	
<i>Protobryum bryoides</i> (Dicks.) J. Guerra et M. J. Cano	+	+	+	+
<i>Pseudocrossidium hornschruchianum</i> (Schultz) R. H. Zander	+	+	+	+
<i>Pterygoneurum ovatum</i> (Hedw.) Dixon	+	+	+	
<i>Rhynchostegium megapolitanum</i> (Blandow ex F. Weber et D. Mohr) Schimp.		+		
<i>Syntrichia ruralis</i> (Hedw.) F. Weber et D. Mohr		+	+	
<i>Tortula lanceola</i> R. H. Zander			+	
<i>Tortula modica</i> R. H. Zander			+	
<i>Weissia</i> sp.			+	+

num). *Riccia* species and *Bryum alpinum* are characteristic members of the bryoflora of salt grasslands in the Hortobágy region of Hungary, where sulphate containing soils occur (BOROS 1968, ORBÁN 1982).

New and interesting records

Didymodon sicculus is a new element of the Croatian bryoflora. It was also reported for the first time in Serbia from this collection (PAPP *et al.* 2011). This species was described from southern Spain by CANO *et al.* (1996). It is a xerophytic plant, which occurs on dry, loamy, saline, and gypsiferous soils. At first, it was thought to be endemic to SE Spain, but later on, it was discovered in many Atlantic and Western Mediterranean regions like the Azores, Balearic Islands, Canary Islands, Algeria, France, Morocco, Portugal, Sicily (ROS *et al.* 2013). In SE Europe it is already known from Albania, Bulgaria, Greece, Montenegro, Serbia, Slovenia, and Turkey (HODGETTS 2015). It also occurs in Hungary in saline areas of the Danube–Tisza Interfluve (unpublished data of Erzberger and Papp).

Microbryum curvicolium is a sub-Mediterranean species (DÜLL 1984), rare in SE Europe; known only from Bulgaria (where it is data deficient (DD)), Croatia, Greece, Romania (where it is endangered (EN)), and Serbia (HODGETTS 2015). It is also red-listed in many Central European countries, e.g. Austria, Germany, Luxemburg, Netherlands, Poland, Slovakia, Switzerland (HODGETTS 2015). It is a tiny moss and was probably overlooked. It was found in the Serbian sites at Trešnjevac and Velebit.

Microbryum floerkeanum was reported for the first time in Serbia from this collection (PAPP *et al.* 2012). It is a sub-Mediterranean, sub-Atlantic element (DÜLL 1984), included in the data deficient category according to the Red data book of European bryophytes (ECCB 1995). Due to its minute size and seasonal appearance, it is frequently overlooked. In SE Europe it is known only from Bulgaria, Croatia, Serbia, and Romania (HODGETTS 2015), where it is critically endangered (ȘTEFĂNUȚ and GOIA 2012). It was found both in the Serbian and Croatian investigated sites.

Entosthodon hungaricus is relatively abundant in the studied Serbian saline areas, but in general a rare species in Serbia and threatened due to its specific ecological features and degradation of its habitat. It is also a character species of the Hungarian saline grasslands (PAPP and RAJCZY 2000). It is a continental-Mediterranean species (DÜLL 1984), included in the rare (R) category according to the Red data book of European bryophytes (ECCB 1995). In SE Europe it is known only from Greece, Romania, and Serbia (HODGETTS 2015). It is endangered (EN) in Serbia (SABOVLJEVIĆ *et al.* 2004). It occurs in some Central European countries, where it is also red-listed, e.g. in Austria, Germany, Hungary, and Slovakia (HODGETTS 2015). In southwestern Europe it is red-listed in the Canary Islands, Malta, and Spain. Besides these it is known from Portugal and Sicily (HODGETTS 2015).

Oxymitra incrassata is a sub-Mediterranean thalloid liverwort (DÜLL 1983) rare in SE Europe, and lacking or red-listed in many SE European countries (HODGETTS 2015). It is vulnerable (VU) in Bulgaria and Slovenia, critically endangered (CR) in Montenegro, missing from Bosnia and Herzegovina, the Republic of Macedonia, and the European part of Turkey (HODGETTS 2015). It was reported from Serbia by SABOVLJEVIĆ *et al.* (2010). A specimen collected by János Guelmino was found in the Herbarium of the Hungarian Natural History Museum, Budapest (BP). This publication has been overlooked by HODGETTS (2015), who erroneously reports it as missing from Serbia. It is also red-listed in all the Central European countries, where it occurs, e.g. Austria, Germany, Hungary, Poland, Slovakia, and Switzerland (HODGETTS 2015). Now the survival of the population in the salt grasslands at Padej is confirmed.

Protobryum bryoides is a sub-Mediterranean species (DÜLL 1984). It is known from almost all SE European countries except Albania and Bosnia and Herzegovina, but endangered (EN) in Bulgaria and vulnerable (VU) in Romania and Slovenia (HODGETTS 2015). It is also red-listed in many Central European countries, e.g. Austria, Netherlands, Slovakia, Switzerland (HODGETTS 2015). Probably it is overlooked due to its seasonal appearance. It was found in all investigated sites, both in Serbia and in Croatia.

Pterygoneurum ovatum is vulnerable (VU) according to the red list of Serbia (SABOVLJEVIĆ *et al.* 2004). It is a species of the European temperate zone (DÜLL 1984), and known from all SE European countries (HODGETTS 2015). It is also red-listed in many Central European countries, e. g. Austria, Germany, Luxembourg, Netherlands, and Switzerland (HODGETTS 2015). Probably it is also overlooked due to its seasonal appearance. It was relatively abundant in the studied Serbian saline areas on disturbed soil, mainly on the bank of channels.

Riccia nigrella is an Atlantic, Mediterranean thalloid liverwort (DÜLL 1983). It was reported for the first time in Serbia by SABOVLJEVIĆ *et al.* (2010). It was separated from an *O. incrassata* specimen collected by János Guelmino in the 1970s, and deposited in the Herbarium of the Hungarian Natural History Museum, Budapest (BP). During our investigation it was re-found on the salt grasslands at Padej. It is known from almost all SE European countries except the Republic of Macedonia, Romania, and Slovenia (HODGETTS 2015), however it has mostly old records in many countries (BISCHLER *et al.* 1980, DRAGIĆEVIĆ and VELJIĆ 2006). From Croatia there is one recent record collected this year (leg. Vuković, Herbarium ZA), in Bulgaria there are two recently known populations (pers. comm. Rayna Natcheva). In the Mediterranean part of Greece it is not rare (BLOCKEEL 2010, 2012, ERZBERGER 2006, SABOVLJEVIĆ *et al.* 2008). In Central Europe it is known only from Switzerland, where it is vulnerable (VU) (HODGETTS 2015).

CONCLUSIONS

During winter and in early spring, when large territories are under water because the soil cannot absorb rainfall, *Drepanocladus aduncus* is very abundant in the studied saline areas, while other bryophytes occur only sporadically at higher elevations, on drier spots. However, from March to April several colonist species appear mainly in the transitional zones of higher plant communities, and on bare soil among tussocks, e. g. *Microbryum*, *Phascum*, *Protobryum*, *Pterygoneurum* species, and *Entosthodon hungaricus* always with capsules, as well as species of the *Bryum erythrocarpum* complex with rhizoid gemmae like *Bryum rudemale*, and *B. dichotomum* with axillary propagules. These species can colonise very quickly the open soil surfaces owing to their intensive production of spores and vegetative propagules. In spots at higher elevation mainly pleurocarpous perennial species occur, e.g. *Brachythecium albicans*, *Homalothecium lutescens*.

In order to preserve the high bryophyte diversity of saline areas the maintenance of mosaic-like arrangements of higher plant communities and grasslands rich in bare soil surfaces is crucial. Sheep grazing is an important factor in the preservation of the structure of saline grassland. As the use of land is changing in Serbia and Croatia, agriculture, especially animal husbandry is declining, these grasslands are threatened by abandonment, which will cause the formation of more dense and uniform stands. The decrease of open soil surfaces and lack of disturbance are disadvantageous for the colonist bryophyte species. The bryophyte diversity would decrease and rarities or conservationally important species would disappear. In Croatia the saline areas are protected, however their extension is very small, surrounded by agricultural lands, hence active conservation management is important. In Serbia these saline areas are not protected and even their future cannot be predicted.

* * *

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Összefoglaló: 40 mohafajt (5 májmohát és 35 lombosmohát) találtunk szerbiai és horvátországi pannon szikes területek vizsgálata során. A következő mohák mind a szerbiai, mind a horvátországi területeken előfordultak: *Barbula unguiculata*, *Brachythecium albicans*, *Bryum algovicum*, *B. dichotomum*, *B. rudemale*, *Didymodon sicculus*, *Drepanocladus aduncus*, *Microbryum davallianum*, *Microbryum floerkeanum*, *Phascum cuspidatum*, *Protobryum bryoides* és *Pseudocrossidium hornschiianum*. Ezeknek a fajoknak a többsége a magyarországi Duna–Tisza közti szikeseknek is tipikus mohája. Egy faj, *Didymodon sicculus*, újnak bizonyult Horvátország mohafőrlőjára. A *Micro-*

bryum floerkeanum szerepel az európai moha vörös könyvben. A szerbiai szikeseken egy másik európai moha vörös könyves faj, az *Entosthodon hungaricus*, is előfordul. Az egyik szerbiai területen talált két telepes májmoha (*Oxymitra incrassata* és *Riccia nigrella*) pedig ritka Délkelet-Európában.

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